

Visual learning capacity and retention in the Tree Shrew (*Tupaia*): an extension¹

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(With three figures—1 in text, 2 inset)

This paper is dedicated to India's foremost ornithologist, Dr Sálím Ali. Even if it does not dwell on birds we venture to offer it to him as a token on the occasion of his 75th birthday as he is also an eminent ecologist, general biologist and conservationist with a deep interest and love of animals: hence *Tupaia* may enter.

Since tree shrews (Tupauidae) have been placed fairly high on the ascending evolutionary scale, and since some authors regard them as the link between Insectivora and Lemurioidea, or even as essentially lemuri-form (e.g. Le Gros Clark 1934, 1959; Simpson 1945), every bit of information concerning their functional, sensory and behavioural performance is welcome as it might shed further light on the human whence and where of his own capacities. The problem of the systematic position of tree shrews is by no means settled as can be seen from the more recent papers by Van Valen (1965: tree shrews and primates not closely related, fossil evidence), Spatz (1967: contrary view, anatomical, histological, behavioural facts) and Martin (1968: behavioural evidence in favour of no close relationship).

To assess the visual learning capacity of an animal one has to rely on a method yielding quantitative results for comparison. Various parameters have been used for comparing animal performance and thus placing various animals on certain systematic and phyletic levels, e.g. learning speed, amount of errors in the learning process, duration of retaining the tasks learned, learning set, etc. The literature on animal learning and retention is vast, and we shall not go into details here.

One method which we used rather early and, as we hope, successfully is the serial rotation test of visual discrimination learning (Altevoigt

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1951). In this method, the animal is required to learn a visual discrimination of two-dimensional patterns in a two-choice set-up, e.g. black cross versus black circle each on white background, and offered as a cardboard to be pushed aside to get the food reward. After the first two-pattern-discrimination has been learned to criterion, the animal learns the next task, say fine stripes versus broad stripes, again offered as black-white patterns on plaques. In this way a number of discrimination tasks can be learned one after the other, the data indicating learning speed, criterion reached, etc.

Serial rotation is introduced after two or more such tasks have been learned to criterion, i.e. then task 1, 2 and 3 are offered one after the other in this sequence or in any other predetermined order, say 3, 1, 2, 2, 3, 1, etc. Obviously, with increasing number of tasks learned, the number of stimulus pairs in each of such sequences increases, and the experimenter will find out just how many of the stimuli will be mastered quasi simultaneously by the animal as it is required to have the correct choices ready, e.g. to know the right (and wrong?) stimulus of pairs 1 to 5 if given the 5 pair serial rotation test. In this manner, especially Rensch and his collaborators have tested a number of animals of various levels from fish to elephants (survey given in Rensch 1962).

The range of visual learning capacity thus determined reaches from a meagre 1 in the opossum (Neumann, 1957) to 20 visually discriminated pairs of patterns in the Indian elephant (Rensch & Altevogt, 1955). Unfortunately, the monkey and ape level has not been touched yet as far as we know, and man himself has not been tested by this method either.

Tigges (1964) applied the method on tree shrews (*Tupaia glis* Diard 1820) 'since they belong to the most primitive level of primates....' (232). He used 3 pairs of black-white and 3 pairs of colour stimuli as discriminanda and found that 'none of the 6 animals was able to retain simultaneously more than 3 different tasks' (240).

This rather poor performance does not compare favourably with the fact that a reasonably 'bright' mouse or rat masters at least 5-6 pairs of visual discriminanda in the serial rotation test (Boxberger 1953; Reetz 1958).

While working on the behavioural physiology and ontogeny of *Tupaia glis* (Zeller 1971) we carried out a series of experiments on the visual learning capacity using the 6 pairs of black-white patterns shown in Figure 1. Thus we eliminated possible experimental errors most often inherent in studies using (pigment) colour stimuli (i.e. proper control of brightness and hue). The discriminanda were 6 × 9 cm in size and could comfortably be duplicated photographically. As they soiled rather often due to the animals' tendency to impregnate paths and objects of their home range olfactorily (for review see Zeller 1971) they were covered by plastic film so that they could easily be cleaned to control

for possible olfactory clues in the discrimination trials. The discriminanda were offered on 2 - 4 small white doors of 10.5×10.5 cm which swung open if the animal touched them—which they did with their

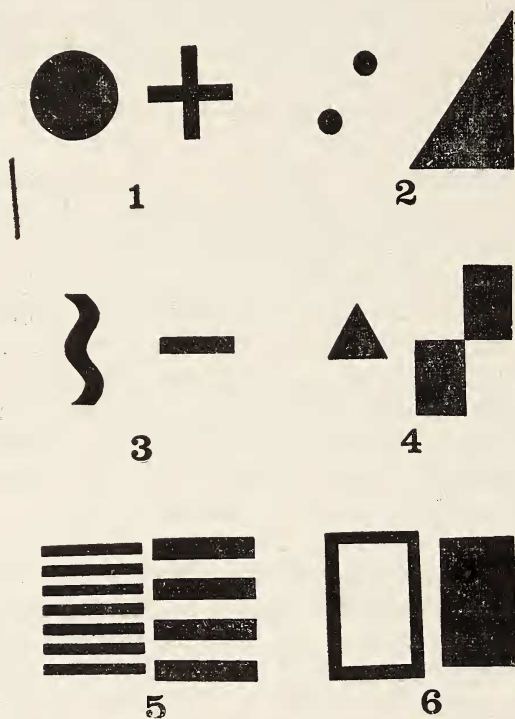


Fig. 1. The six pairs of discriminanda used in choice experiments with *Tupaia glis*.

snout or hands. The experimental animals were given access to the discriminanda from a starting platform (bottom, Fig. 2) at a maximum distance of 50 cm from where they could view the discrimination pairs as shown in Fig. 3. Illumination by hidden bulbs resulted in a brightness level of 285 lux measured 18 cm in front of the discriminanda. After choosing the positive pattern, i.e. opening the respective door, the animal found the food reward (biscuit, lettuce, meat).

To control for spontaneous preferences, the animals were first presented with both stimuli of each pair food-baited, and the pattern spontaneously preferred was given negative meaning, i.e. would not be rewarded subsequently.

For the daily trials the animal's living cage was connected to the choice apparatus by an alley, thus giving free access to the starting platform and keeping the animals' disturbance due to handling etc. at a minimum.

Experiments were run between 9 and 11 a.m. (sometimes to 1 p.m.), with food and water given ad lib. from afternoon to night. Normally there were 25 trials per day and animal.

The learning criterion was 5 consecutive days with at least 25 trials each and more than 75% correct runs per day (this is a higher criterion than that used by Tigges, who chose 72.1% on 5 successive series following Koller's [1953] statistics).

All animals were housed individually in cages of 100 × 60 × 75 cm with a smaller sleeping and eating box of 20 × 20 × 17 cm. Room temperatures were 27 - 30°C and relative humidity was kept at 30 - 50%. Apparently this regime suited the tree shrews fine, as within 2 years the 7 animals we started with produced 19 young (for details see Zeller 1971).

From our animals we chose one ♀ and one ♂, both 1 year old at the beginning of the experiments, for the study of visual learning capacity. This small number would do as we only wanted to find out whether Tigges's findings could be extended or if indeed *Tupaia* must be credited with such a limited visual learning capacity as indicated in his paper.

Single tasks



Spontaneously the two animals showed the following preferences (Table 1):

Task No. ..	1		2		3		4		5		6	
♀ ..	9	11	—	20	17	3	9	11	7	13	6	14
♂ ..	8	12	7	13	10	10	8	12	10	10	10	10

Table 1. Figures indicate number of choices of respective pattern in 20 trials with both stimuli rewarded.

Correspondingly, if there was a strong preference of a particular pattern it was given negative meaning and vice versa.

Learning the discriminanda, offered as pairs indicated and in the order of Table 1, was mastered by both animals without difficulty except pair no. 3 ('snake' versus bar) which was learned by the male with a good record (80, 80, 88, 92, 88%: average 85.6% over 5 days with 25 trials each), but which could not be mastered by the female, who failed to reach criterion in 21 days. She was therefore offered another (i.e. 7th)

pair of discriminanda:  versus  yielding 76, 80, 76, 84 and 76%

correct choices, hence reaching criterion.

The respective correct choices by our test animals shown at the various visual tasks 1-6 are tabulated in Table 2.








Task	♀%	♂%	Average %	
			♀	♂
	76, 80, 84, 84, 88	80, 84, 80, 84, 92	82.4	84
	84, 100, 100, 100, 100	88, 96, 84, 92, 88	89.6	98.8
	— — — — —	80, 80, 88, 92, 88	<75	85.6
	84, 80, 92, 80, 80	92, 96, 96, 96, 96	83.2	95.2
	— — — — —	76, 84, 88, 80, 80	<75	81.6
	96, 88, 88, 80, 88	80, 88, 80, 88, 76	88	82.5
	76, 80, 76, 84, 76	— — — — —	78.4	<75

Table 2. Correct choices (%) by *Tupaia*, in 5 series of 25 trials each leading to learning criterion.

	Number of tasks			
	2	3	4	5
♀	91.6	92.5	96.1	<75
♂	91.6	94.4	90.9	92.5

Table 3. Serial rotation test in *Tupaia*. Correct choices (%) in 2-, 3-, 4-, and 5-task test.

As can be seen from Table 3, both animals not only mastered the 3- and 4-task test in serial rotation with good results, but showed even better percentages of correct choices than in the single task tests. Thus, task 1 had yielded 82.4 and 84% in the single (see Table 2), but in the serial rotation of tasks 1 and 2 both the animals reached 91.6%. This finding is in accordance with data by Altevogt (1951) in chickens, by Rensch & Altevogt (1955) in the Indian elephant, and by various authors applying the same method on various animals (see Rensch 1962, for review). Possibly, the animal's attention and willingness to discriminate is aroused to a larger degree by the continuously changing order of discriminanda which may be less 'boring' than having to work on the same pair of patterns for a longer time.

Due to the fact that the female had not reached criterion in tasks 3 and 5, her 3-task test comprised pairs 1, 2, and 4, while in the male it was 1, 2, and 3. Both animals, however, scored excellently (♀ 92.5%; ♂ 94.4%).

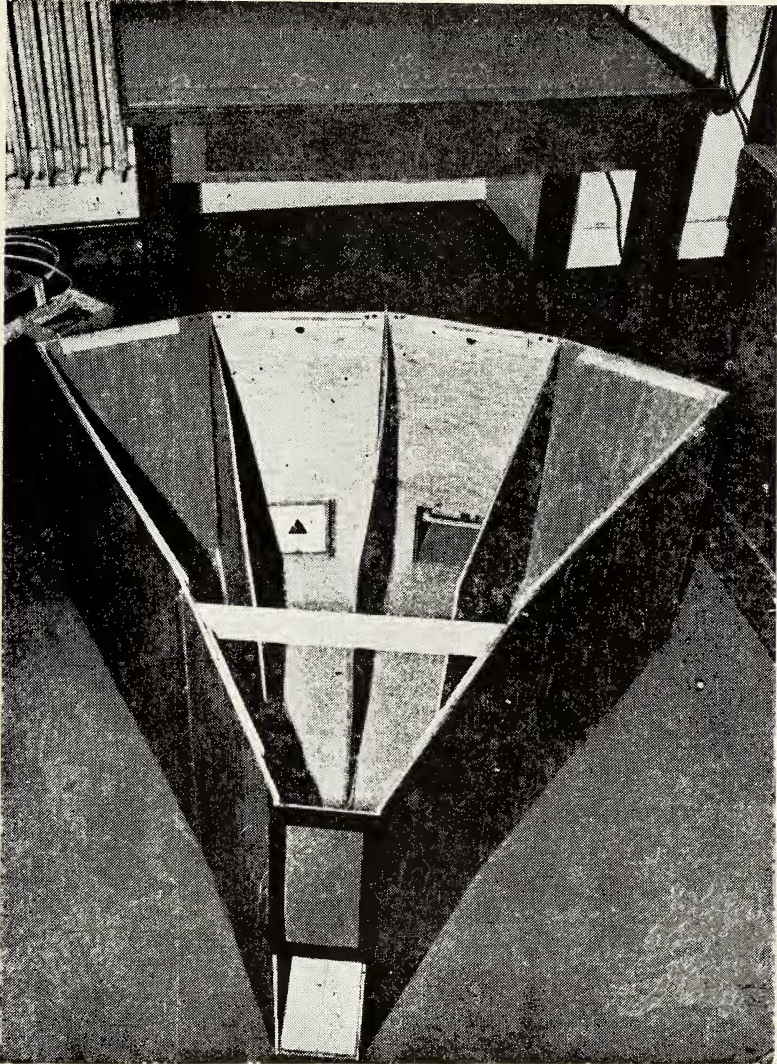


Fig. 2. Visual discrimination apparatus. Starting platform at bottom.

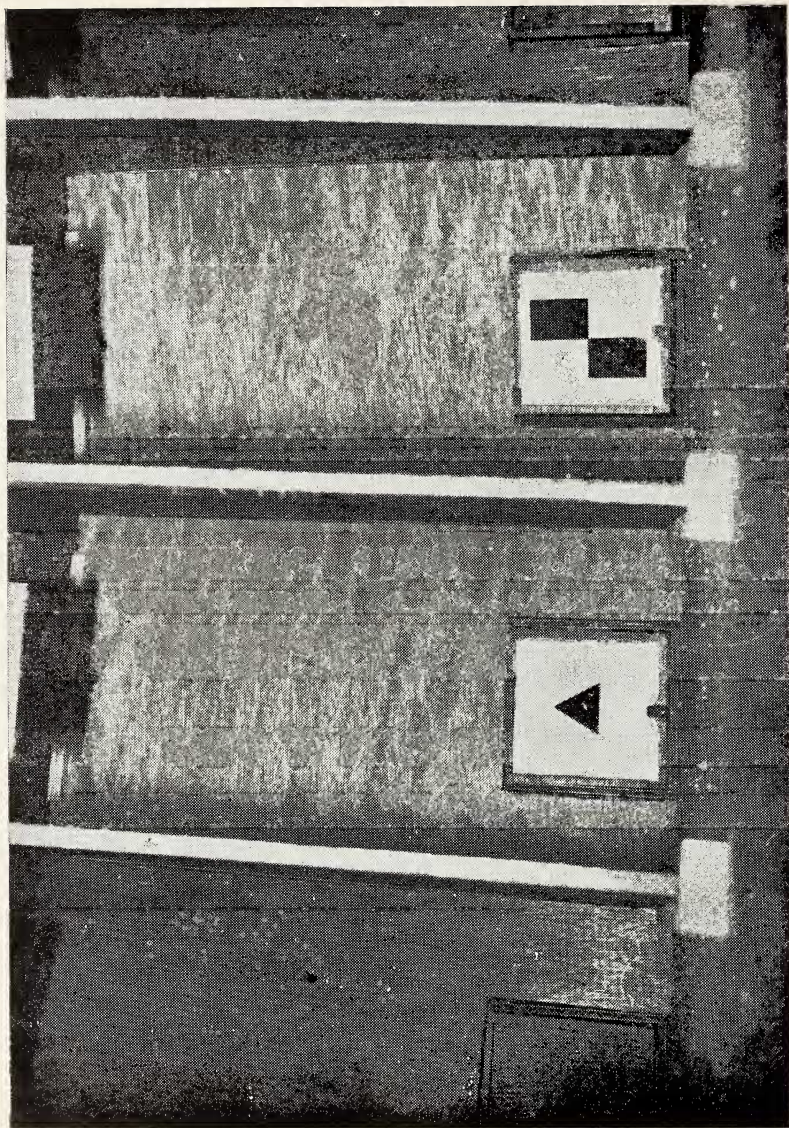


Fig. 3. A pair of discriminanda on swinging doors, animal's view.